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PERFORMANCE TESTS ON THE KOHMYR ECC OZONE SONDE

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This report contains the results of a study carried out to provide information on the reliability and accuracy of the Kohmyr ECC ozone sonde (ref. 1) as manufactured by Science Pump Corporation[2] and flown by the NOAA Weather Station, Wallops Island, Virginia. The study was made during the period of August 8-15, 1975, in cooperation with NOAA Weather Station and Wallops Station NASA personnel.

After minor repairs, the Weather Station's Dasibi Environmental Corporation ozone monitor was adjusted to operational tolerances, following the procedures outlined in the manual provided with the instrument. This ozone monitor and another Dasibi monitor from the Old Dominion University laboratory were then connected to a common ozone source for an intercomparison of calibrations. Agreement within $\pm$ 2 ppbv was observed over the range 0-500 ppbv.

The ECC ozone sonde preparation procedure described in the manufacturer's manual (ref.3) includes some checks on sonde performance. Additional emphasis should be placed on establishing and testing for leak-free connections and stable pump flow rates.

As indicated by the manufacturer (ref.3), pump motor regulation breaks down at voltages less than six volts. The magnitude of this effect was determined experimentally and found to be quite large (fig.1). This could be of particular significance towards the end of a flight, or in cases where the current drain on the battery is unusually high.

Emphasis should also be placed on properly adjusting the pumping pressure. As shown in figure 2, the flow rate is acutely sensitive to pump pressure setting at pressures less than three inches of mercury. Higher pressures

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should be avoided, however, because of the possibility of excessive current drain on the batteries.

To check the calibration of the Kohmyr ECC ozone sondes, two ozone sondes were prepared for operation according to the manufacturer's instructions (ref.3). Each ozone sonde was then connected to 1680 mHz radiosondes which telemetered ozone data to a ground-based receiving station. The data was recorded on strip chart recorders in the normal fashion (ref. 3). Chart ordinate data was transformed to ozone concentration data as outlined in reference 3, except that S = 294 s/k replaced the equation S = 314 s/k found in Appendix L of reference 3. This change was recommended by Weather Station personnel because of design changes in the radio sondes occuring since publication of the manufacturer's instructions.

Raw ordinate data are shown in tables 1 and 2 for each of the sequencing switch positions. Ozone concentration data calculated from the ordinate data in tables 1 and 2 are given in tables 3 and 4. The results of a linear regression treatment of the sonde-indicated ozone concentration vs Dasibi readings for each switch position are included in these tables, along with averages of the regression parameters over the six sequencing switch positions.

For sonde 2A085, the six slopes obtained from the regression analysis of the individual switch positions are not statistically different. The mean of the six slopes was 0.762 $\pm$ 0.9%, with an average uncertainty in each of the individual slopes of 3%.

For sonde 2A098, the mean value of the six slopes was found to be 0.766 $\pm$ 2.7%, with an average uncertainty in the individual slopes of 1.7%. This indicates a possibly real statistical difference between switch positions, perhaps as a result of differing contact resistances.

The averages of the six intercepts obtained for each sonde are clearly non-zero and different (9.46 = 34% for sonde 2A085 and -4.34 = 49% for sonde 2A098). For either of the sondes, the six intercepts are probably not statistically different.

CONCLUSIONS AND RECOMMENDATIONS

The agreement between the average slopes found for each of the two ozone sondes (0.762 and 0.766) is quite good. In view of the relative uncertainties associated with each average slope (0.9% and 2.7%), however, the agreement is probably fortuitous.

Both slopes are significantly different from the theoretical value of 0.987 predicted on the assumption of exact agreement between sonde ozone values and Dasibi values and, also, assuming accurate Dasibi calibration. (The nonunity slope is a result of different measurement units; Dasibi readings in ppbv and sonde values in μmb). The slope errors are probably not as large as they appear because of uncertainties in the calibrations of Dasibi instruments. Preliminary studies carried out in Old Dominion University laboratories have shown the Dasibi to indicate ozone concentrations about 15% higher than values measured by the neutral buffered KI technique designated by EPA as a reference method (ref. 2). The apparent error in the slopes may thus be only about half of that indicated by inspection of the slope values reported.

In view of the importance of obtaining accurate stratospheric ozone measurements, it is suggested that sondes be individually calibrated before flight. This could be accomplished using a stable ozone source in conjunction with the Dasibi monitor. The Dasibi, in turn, should be subjected to a careful calibration by two independent methods such as the gas-phase titration method (ref. 4), traceable to weight and volume standards, and the neutral buffered KI method (ref. 2).

The nonzero intercepts observed from each sonde are probably due to errors in the background current attributed to oxygen. Some consideration should possibly be given to modifications in the ozone-destruct filter during the background current measurements, in order to remove reactive interferents.

REFERENCES

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3. Instruction manual for model ECC-LA electrochemical concentration cell ozone sonde, Science Pump Corp. 1431 Ferry Avenue, Camden, NJ 08104.

4. J. A. Hodgeson, R. E. Baumgardner, B. E. Martin and K. A. Rehne, Stoichrometry in the neutral iodometric procedure for ozone by gasphase titration with nitric oxide, Anal. Chem. 43, 1123 (1971).

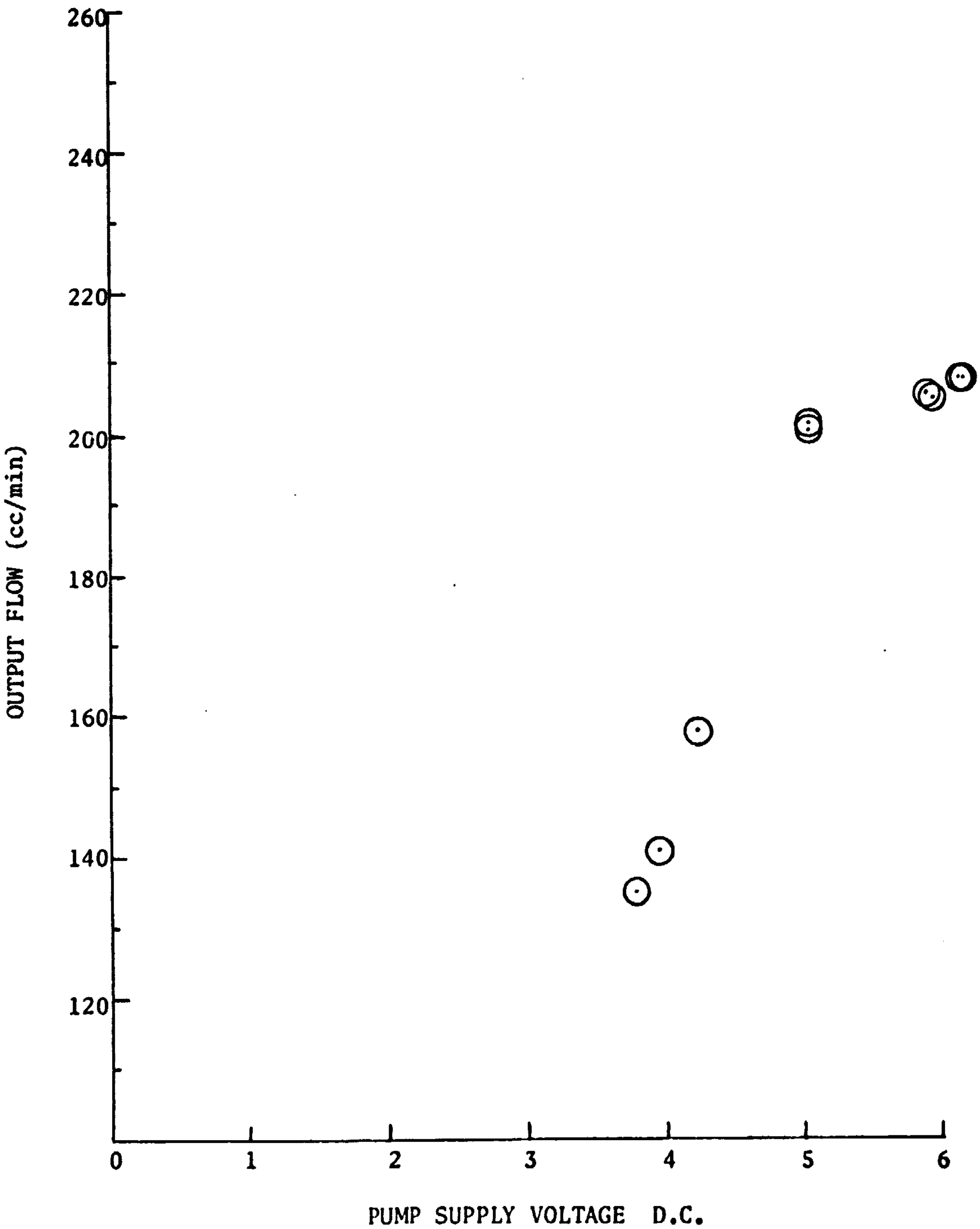

Figure 1. Sonde flow rate as a function of pump voltage (Sonde 2A085).

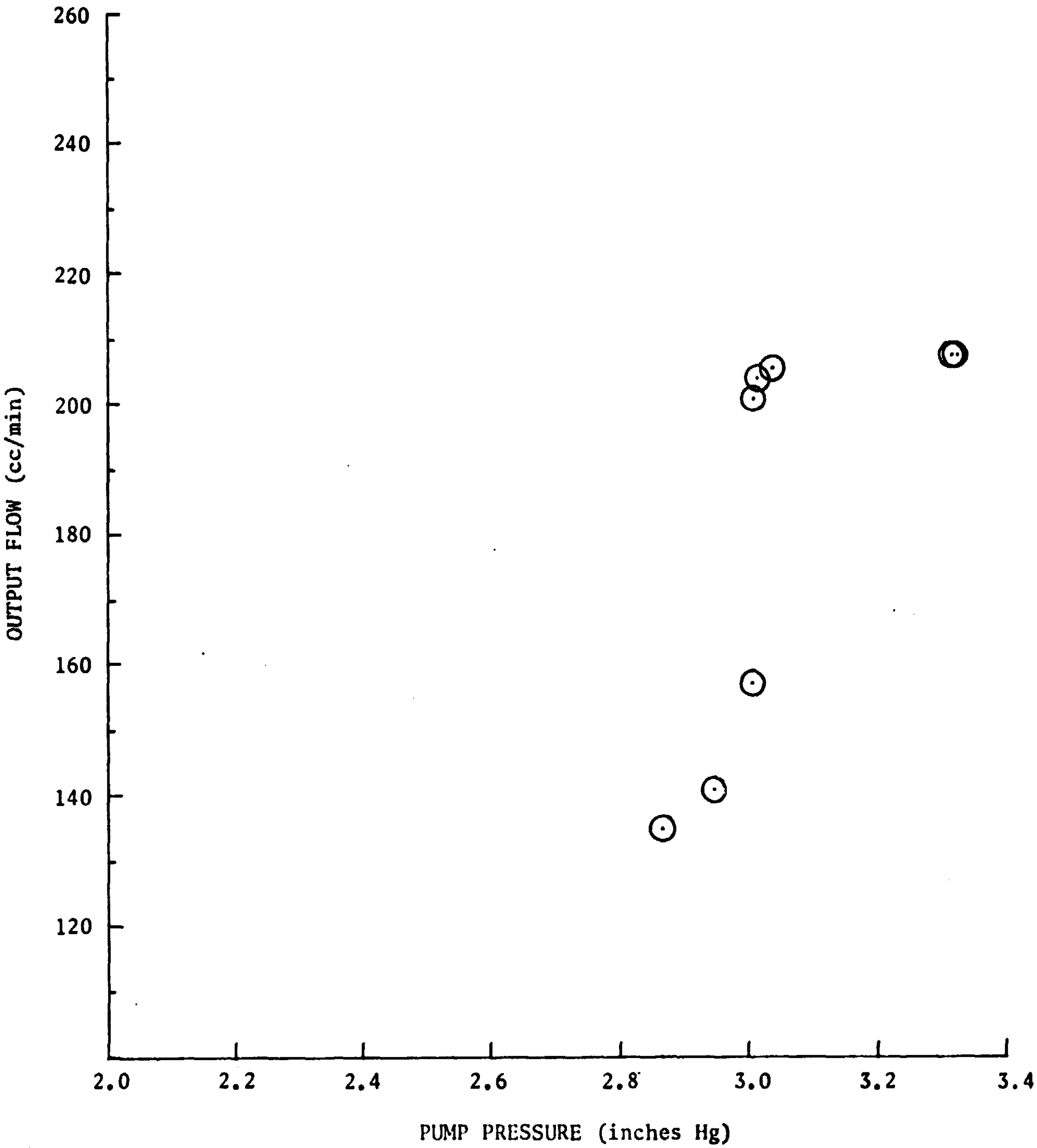

Figure 2. Sonde flow rate as a function of pump pressure (Sonde 2A085).

Table 1. Raw Calibration data for 2A098 Ozone Sonde *

$[O_3]$**	Z+	O_1	Tb$	O_2	O_3	C#	O_4	O_5	O_6
0	39.0	75.8	75.8	43.0	42.2	63.2	40.5	40.2	41.2
0	39.0	75.8	75.8	42.8	42.5	63.2	40.0	40.2	41.0
0	39.0	75.8	75.8	41.5	41.5	63.5	41.5	40.8	41.0
20	39.2	75.8	75.8	42.0	43.0	63.8	42.8	43.0	44.0
20	39.2	75.9	75.9	44.5	44.5	63.9	43.5	43.5	44.2
50	39.6	76.0	76.0	44.8	44.8	64.0	48.5	51.8	51.5
62	39.8	76.0	76.0	50.5	50.2	64.2	50.0	50.0	50.5
65	39.8	76.0	76.0	50.8	51.0				
104	39.8	76.0	76.0	55.5	55.5	64.5	55.2	55.3	55.6
107	39.9	76.0	76.0	55.8	55.8	64.8	55.8		
166	40.0	76.2	76.2	63.2	63.5	65.0	63.5	63.5	64.0
172	40.0	76.0	76.0	64.2	64.0	65.0	64.0	64.0	
324	40.0	76.2	76.2	85.2	85.2	65.5	85.2	85.2	85.5
220	40.1	77.5	77.5	81.5	77.5	65.5	74.5	74.0	73.8
223	40.2	76.2	76.2	74.0	74.0	66.0	74.2	74.2	74.8
231	40.2	76.0	76.0	75.2	75.2	66.5	75.8	75.8	75.9
231	40.2	76.0	76.0						

* All ozone sonde data is in chart ordinate units with fullscale at 95

** Ozone in ppb obtained with Dasibi ozone monitor

\+ Zero reading

\# Electronic internal calibration

$ Box temperature

Table 2. Raw Calibration data for 2A085 Ozone Sonde*

O_3^{**}	Z^{+}	$O_1^{\$}$	Tb	O_2	O_3	$C^{\#}$	O_4	O_5	O_6
0	39.5	39.8	75.8	40.0	40.2	66.4	39.5	40.2	41.0
0	39.2	39.7	75.8	40.0	40.2	66.6	40.1	40.2	41.5
17	39.9	40.0	75.6	40.2	40.4	67.0	42.5	43.2	44.2
20	40.0	44.0	75.8	44.5	44.8	67.2	44.0	44.2	44.9
20	40.0	44.2	75.9	44.8	45.0	67.2	47.0		
62	40.0	51.6	76.0	51.2	51.3	67.8	50.8	51.0	51.4
66	40.1	51.2	76.0	51.5	51.5	67.8	54.8		
103	40.2	57.0	76.0	56.5	57.0	68.0	57.0	57.0	57.2
107	40.2	57.2	76.0	57.8	57.8	68.4	58.0		
173	40.8	66.2	76.2	67.5	67.0	69.2	67.0	67.2	67.2
323	39.2	87.2		87.2	87.8	68.8	86.3	87.6	87.6

* All ozone sonde data is in chart ordinate units with fullscale at 95

** Ozone in ppb obtained with Dasibi ozone monitor

\+ Sonde electronic zero

\# Electronic internal calibration

$ Box temperature

Table 3. Comparison of Dasibi and ECC ozone monitoring devices for sonde #2A085

Dasibi (ppb)	ECC Sonde (μm bar)					
	Contact Number					
	1	2	3	4	5	6
0	2	3	4	0	4	9
0	1	3	4	3	6	12
17					19	25
20	23	26	28	23	25	29
62	65	63	64	61	62	64
103	94	91	94	94	94	95
107	93	97	97	98		
173	136	143	140	140	141	141
323	252	252	255	248	254	254
intercept	7.90	8.56	10.2	8.51	8.59	13
slope	0.765	0.765	0.767	0.760	0.768	0.749
std error	6.67	5.92	5.52	6.91	13.7	3.31
error-intercept	3.28	2.06	2.72	3.40	6.29	1.5
error-slope	0.023	0.015	0.0192	0.024	0.046	0.011
corr. coef.	0.9973	0.9976	0.9981	0.9970	0.9880	0.9993

<u>Averages over the 6 data sets*</u>

intercept	9.46 ± 1.89
slope	0.762 ± 0.007
std error	7.00 ± 3.52
intercept error	3.2 ± 1.67
slope error	0.023 ± 0.013
corr. coef.	0.9962 ± 0.041

* Errors given here are standard deviations for the six data sets.

Table 4. Comparison of Dasibi and ECC ozone monitoring devices for sonde #2A098

Dasibi (ppb)	ECC Sonde (μm bar)					
	Contact Number					
	1	2	3	4	5	6
0	0	15	-1	-12	-14	-7
0	-3	3	1	-15	-15	-9
0	-4	-6	-6	-6	-10	-9
20	12	12	12	6	6	10
62	49	47	44	44	44	
65	49	49	50			
104					75	77
108	80	78	78	78		
166					121	124
172	125	125	124	129	124	124
324	233	234	234	234	234	236
intercept	-1.46	0.32	-0.788	-8.23	-9.83	-6.07
slope	0.752	0.745	0.743	0.787	0.789	0.777
std error	4.3	4.71	3.8	6.1	5.73	4.52
error-intercept	1.71	2.02	1.64	2.74	2.59	2.03
error-slope	0.011	0.013	0.011	0.016	0.015	0.012
corr. coef.	0.9988	0.9986	0.9991	0.9981	0.998	0.9988

Averages over the 6 data sets

intercept	-4.34 ± 4.26
slope	0.766 ± 0.021
std error	4.8 ± 0.88
intercept error	2.12 ± 0.45
slope error	0.013 ± 0.002
corr. coef.	0.9986 ± 0.0004